Managing Design Risk

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Design is the first activity that has to be carried out in a construction project before construction can commence. Getting the design right requires managing the design risks to minimise the chance that the constructed facility will not fulfil its anticipated time, cost and quality requirements. There are two categories of design risks – the design management risks and the technical risks. The design management risks are those that relate to the designer's performance in preparing the design and ensuring the design is constructed correctly. The technical risks are those that impact other stakeholders because of the content of the design. The tasks of appropriately "controlling" design management risks are both internal and external to the designer. Internal "control" of the risks requires the designer to have robust procedures in place to manage the design and construction inspection process. The external design management risks are those under the "control" of the designer's employer. Managing the technical risks involves detailed review to check that the required outcomes for construction and the completed facility are achieved. The thesis of the article is that both design management risk and technical risks can generally be managed successfully by using an appropriate design contract to engage a qualified designer who applies established risk management procedures and complies with the design contract.

Introduction

The design of a facility is the first activity that has to be carried out before construction can commence. The design involves all the large and small decisions required to determine what is to be built: its form, how its elements work individually and in combination to fulfil their functional requirements, what materials will be used in construction, how these are connected, how the facility is to be constructed, and how it should be maintained and operated. The design may constrain the methods of construction and limit the number of potential contractors by requiring particular construction equipment. It is the design that determines the economic characteristics of the constructed facility such as its durability, the ongoing operating and maintenance costs and ultimately its commercial life. Most importantly, the design determines the performance, functionality and economy of operating the completed facility over its lifetime, the cost of which may be two orders of magnitude greater than the cost of the design.

The significance of design cost in relation to the lifetime costs of a project is succinctly encapsulated in the 1:10:100 "rule" originally formulated by Crosby,[1] and applied to construction by Tilley:

> In construction, this rule would mean that changes made during the pre-design phase would have a proportional impact of $1 to the project. However, if not identified early enough, the cost would increase to $10 during the design phase and up to $100, if left until construction had begun. Extending this concept to post occupancy, then the cost of rework to implement changes not picked up previously, could be as high as $1000.[2]

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[1] PB Crosby, *Quality Is Free: The Art of Making Quality Certain* (New American Library, 1979).

[2] P Tilley, "Lean Design Management – A New Paradigm for Managing the Design and Documentation Process to Improve Quality" (January 2005) <https://www.researchgate.net/publication/228684817_Lean_Design_Management-A_New_Paradigm_for_Managing_the_Design_and_Documentation_Process_to_Improve_Quality>.

A broader formulation is the 1:10:100 "cost of quality rule": it makes more sense to spend $1 on prevention than to spend $10 on correction which is preferable to spending $100 on a failure.[3] The "right" design will avoid the necessity for modification and is a prerequisite for a successful project; it is therefore fundamental to minimising the risks in construction and the subsequent operational risks.

The best value in procuring a project will be achieved by focusing on cost effectiveness rather than lowest cost. For example, European Union Directive 2014/24/EU requires public contracts to be based on the most economically advantageous tender (MEAT), which requires the use of a cost-effectiveness approach such as life cycle costing. Criteria for determination of the MEAT may include aspects such as quality, including technical merit, aesthetic and functional characteristics, accessibility, design for all users, social, environmental and innovative characteristics and trading and its conditions.[4] All of those criteria are determined by the design.

Design Risks

Getting the design right requires managing the design risks to minimise, to the extent achievable, the chance that the constructed facility will not fulfil its anticipated time, cost and quality requirements.

In the author's view, there are two distinct categories of design risks – the *design management risks* and the *technical risks*.

The design management risks are those that relate to the designer's performance in preparing the design and ensuring the design is constructed correctly – delivering the design timeously, within the agreed cost, satisfying the appropriate formal quality requirements (eg review, checking and QA procedures) and inspection and reporting non-conformances during construction. Materialisation of design management risks impact either or both the designer and the designer's client who commissioned the design. These parties will be referred to as the Designer and the Employer.

The technical risks are those that also impact other stakeholders because of the content of the design, for example the risk that the constructed design will cause injury to persons or property because it is inadequate to sustain the environmental forces it is subjected to, the design is not constructable with the available technology, or the completed facility does not satisfy the Employer's functional and performance requirements.

A satisfactory design on paper (or these days in the cloud) may be unsatisfactory if it is not implemented correctly. The constructors may misunderstand the design documentation or choose not to follow it to save time or cost. Accordingly, there are sound reasons for the Designer to be involved in inspections during construction to ensure that the design intent is implemented and minimise the risk that the design is not followed in the field.

The following table identifies some of the design management risks and technical risks that have contributed to known failures, along with the party that has "control" of them. "Control" is referred to in the Abrahamson sense, that is if the risk materialises it will be due to wilful misconduct or lack of reasonable efficiency or care by the party with control.[5]

[3] Making Strategy Happen, *The Cost of Quality: The 1-10-100 Rule* <https://www.makingstrategyhappen.com/the-cost-of-quality-the-1-10-100-rule/>; Total Quality Management, *What Is 1-10-100 Rule?* (25 February 2009) <https://totalqualitymanagement.wordpress.com/2009/02/25/what-is-1-10-100-rule/>.

[4] *Directive 2014/24/EU of the European Parliament and of the Council of 26 November 2014 on public procurement*, Art 67.

[5] Max Abrahamson, "Risk Management" (1984) 2 ICLR 241, 244.

	Party with "Control" of Risk	
Risk	**Employer**	**Designer**
Design management risks		
Inappropriate procurement process for Designer	X	
Inappropriate design contract conditions	X	
Inadequate design fees	X	
Inadequate time for design	X	
Inadequate involvement of Designer in construction	X	
Cost of design changes	X	
Inadequate management and supervision of design team		X
Inadequate resourcing of design team		X
Insufficient design skills		X
Unavailability of key personnel		X
Late completion of drawings		X
Designer not fulfilling contractual obligations of site inspection		X
Technical risks		
Poor quality design		X
Design errors		X
Inadequate checking of computer analysis of design		X
Inadequate checking by Designer of contractor's shop drawings		X
Inadequacy of design standards	?	?
Unknown technical risks	?	?
Buildability		X
Cost of implementing final design	X	

Controlling Design Management Risks

As the table above indicates, the tasks of appropriately "controlling" design management risks are both internal and external to the Designer.

The external design management risks are those under the "control" of the Designer's Employer. Procuring the "right" design starts with the Employer's selection of the appropriate Designer who has the managerial skills and resources to deliver the design and the technical skills to deliver an appropriate design that satisfies the design brief. The Employer is responsible for specifying a scope of work that meets its needs and that the Designer can deliver. This includes clear functional and performance requirements, and an adequate level of inspection during construction, allowing the Designer sufficient time to prepare and check the design, and paying the Designer adequately for the required scope of work. The Designer has little influence over those risks identified in the table above as under the "control" of the Employer. It must generally accept the scope of the design and inspection during construction offered by the Employer and may be under commercial pressure to accept inadequate fees for the scope of work or insufficient time to carry out the design.

Having entered into an agreement with the Employer to carry out a specified scope of work for an agreed fee within a specific time, the Designer has "control" over how it carries out the design, and therefore internal "control" of those risks that it can manage. The Designer should have robust procedures in place to manage and supervise the design team and monitor and report progress to an agreed program. It will need to manage the interfaces with parties whose work impacts the design and ensure that the technical risks are managed by appropriate checking procedures. Adequate inspections during construction to monitor conformance with the design need to be properly resourced and carried out. Employer changes can disrupt a well-planned design program and involve scope creep unless properly managed by a formal change procedure.

The design management risks are essentially known knowns.

Managing Technical Risks

Managing the technical risks involves detailed review to check that the required outcomes for construction and the completed facility are achieved. Review techniques include sensibility checks, risk workshops, design reviews, peer review, HAZIDs,[6] HAZOPs[7] and independent certification. The selection of the most appropriate techniques for a particular design will depend on its importance, the consequences of failure and the available resources. The degree of review may be inappropriately constrained by insufficient time or inadequate fees.

The technical risks will typically include both known knowns and known unknowns. Where new technology is being implemented there may in addition be unknown unknowns. In situations where the appropriate technology exists but is unknown to the designer there will also be unknown knowns.

Latent ground conditions are a typical example of known unknown risks. Irrespective of the amount of investigation that has been carried out, there is always a risk that ground conditions may be encountered that were unforeseen from the geotechnical report. The possibility of such unforeseen ground conditions is known, but the type and extent of the unforeseen (latent) ground conditions is unknown.

The Ekofisk tank and complex of offshore platforms in the North Sea is an example of unknown known risks that materialised. After the field commenced operations the settlement of the platforms and the large tank were regularly monitored and appeared to be of no concern, as there was no significant differential settlement between the platforms and the tank. However, the surveying was carried out from structures within the complex and did not detect substantial settlement of the seabed under the entire complex. All of the structures had to be raised by a number of metres to reinstate the design wave requirements. The risk of settlement of the seabed due to the withdrawal of large volumes of hydrocarbons from under the seabed was a known risk, however the extent and magnitude of the settlement was unknown as a result of the inadequate monitoring technique.

The well-known failure of the Tacoma Narrows bridge in Washington in 1940 (Galloping Gertie) is an example of the materialisation of unknown unknown risks. The use of a plate girder deck structure instead of the traditional and stiffer truss did not absorb the turbulence of the wind gusts. In a moderate wind of around 67 km/h the bridge assumed large amplitude torsional vibrations that caused the failure of suspenders and the break-up of the deck structure. The effect of low speed winds on such a structure was unknown at the time, as was the need to design long span bridges for aerodynamic forces.

Where the designer is aware of risks or the possibility of them, it is their duty to warn the Employer of those risks so that the Employer can decide whether it is willing to accept those risks or pay for a more expensive solution. For example, cutting-edge technology may promise cost savings, but it will be attended by increased risk due to lack of experience.

The importance of warning the Employer of risks cannot be overemphasised, as failure to warn in circumstances where the Designer knows of a risk could result in the Designer being found liable. An example of this was a swimming pool constructed in the notorious and highly compressible Coode Island Silt (CIS) in Melbourne. A piled foundation would have eliminated the risk of construction in the CIS, but the Designer perceived that the Employer was not prepared to pay the higher cost of piling, and

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[6] A HAZID is a workshop with a multi-disciplinary team to identify potential hazards. A HAZID typically examines all reasonably possible sources of hazard during project design, construction, installation and decommissioning activities, and for proposed changes to existing operations.

[7] A HAZOP is a structured and systematic workshop technique for identifying potential hazards in a system and identifying operability problems.

therefore designed the swimming pool to be supported by the CIS without piles. The Designer failed to warn the Employer of the risk of movement due to the nature of the soil. This risk materialised, and the swimming pool suffered substantial movement and cracking. The engineer was found to be negligent in its failure to warn the Employer of the risk of movement.[8] The Employer was thereby denied the opportunity of assessing whether it was prepared to make the additional investment in piles to eliminate the risk of movement from the CIS. The message from this case is clear: it is necessary to advise the Employer the basis of design and explain the inherent risks that are known, so that the Employer can make an informed decision on the trade-off between risk and level of investment it wishes to make.

Case Studies on Design Management Risks

Inappropriate Procurement Process for Designer

Burnaby Supermarket Parking Deck

Part of a rooftop parking deck of a one-storey regional community centre collapsed on opening day. The Government appointed a Commissioner to investigate the failure, and his report detailed the probable technical cause of the collapse and also reviewed the many procedural deficiencies that allowed a design deficiency to cause failure.[9] The numerous contributing procedural and contractual problems identified included:

- competitive bidding for design services;
- unclear assignment of responsibilities;
- inadequate involvement of designers during the construction phase;
- poorly monitored changes during construction;
- incomplete peer review; and
- inadequate professional liability insurance.[10]

Inappropriate Design Contract Conditions and Management

Scottish Parliament House

The new building for the Scottish Parliament was required to be of such a quality, durability and civic importance as to reflect Parliament's status and operational needs. The budget cost set in 1998 was £50 million, based on an area of 20,740 m^2. An international architectural competition was held to select a designer. The winning design was a striking and complex collection of buildings with high-quality materials and some unusual design and construction features. The initial concept design area was 27,610 m^2, estimated to cost £62.6 million.

The floor area had grown to approximately 33,000 m^2 in the final design, and the forecast final cost was £431 million in 2004. The building was originally planned to be opened in July 2001 but was only opened in October 2004. The inevitable public criticism of the substantial time and cost overruns culminated in a public inquiry conducted by Lord Fraser QC.[11]

Lord Fraser's report identified many contributing factors to the project performance, including the architect's performance and the client's management. The architectural team comprised a joint venture between a "signature" Spanish architect who prepared the winning concept design, and a Scottish firm of architects. The team was split between offices in Barcelona and Edinburgh with disparate styles, who did not communicate with each other, and failed to meet the timetable or prepare designs within the budget. The building brief was not changed in response to extensive design development and did not convey appropriate messages in respect to time or budget. The client's timetable was unrealistic, did not

[8] *Pullen v Gutteridge, Haskins & Davey Pty Ltd* [1993] 1 VR 27.

[9] Government of British Columbia, Victoria BC Canada, *Commission of Inquiry, Station Square Development* (1988).

[10] D Charrett, *Contracts for Construction and Engineering Projects* (Informa Law from Routledge, 2nd ed, 2022) 268.

[11] Scotland, *A Report by the Rt Hon Lord Fraser of Carmyllie QC, The Holyrood Inquiry*, SP Paper No 205 (2004).

provide adequate time for the complexities of a high-quality design and was irreconcilable with other project objectives.[12]

Inadequate Design Fees

Heathrow Express Tunnel

Heathrow Express is a high-speed rail service from London to Heathrow airport and required construction of a spur line from the London-Bristol line. The spur line required construction of sections in cut and cover tunnel, a length of tunnel under the Heathrow runways and a station and tunnels at the central terminal area and terminal 4.

The airport owner, BAA, engaged consulting engineers to carry out layout planning and supervision of site investigation, and subsequently appointed a Contractor who had responsibility for the detailed design as well as construction of the tunnels.

The construction contract allowed for construction of the station tunnels through the London clay by the method of informal support (also known as the New Austrian Tunnelling Method (NATM)), a method of construction which relies on primary support by the use of bolts, dowels, anchors, mesh, arches and sprayed concrete. This was a novel system for tunnelling in London clay and depends on control by design through observation and monitoring.

Monitoring of deflections during tunnel excavation was carried out, and the project management team expressed some concern with the results, although no action was taken by the Contractor. A substantial collapse of a significant length of tunnel occurred subsequently. Although there were no injuries, substantial, expensive and time-consuming remedial work was required. The cost of the failure on a project with a tender price of £60 million was £220 million for the impact on airport works, and £200 million for the disruption of construction of the adjacent Piccadilly Line Extension. The Contractor was fined £1.2 million and the specialist tunnel design consultant £0.5 million for breaches of health and safety legislation. The Health and Safety Executive conducted an enquiry into the collapse,[13] and identified the technical and organisational causes of failure.[14]

Although the failure clearly had immediate "technical" causes, Muir Wood suggests that one of the underlying causes of the collapse was inadequate design fees. Cost pressures on the specialist tunnel design consultant at tender time resulted in insufficient resources to provide even minimal control of the work, and it did not have appropriate powers of control over the construction. Because of the nature of the tunnelling works and because the contract required the Contractor to certify the quality of its own work, an adequate system of design control of the work should have been specified at tender time.[15]

Inadequate Time for Design

Channel Tunnel

The Channel Tunnel between England and France might have had the longest gestation period of any project in history, as it was first mooted in 1750. Alas, this long gestation period was not put to good use in preparing detailed designs before the ultimate contract was entered into. Only seven months was provided for preparation of proposal. In that time, promoters had to prepare a response which satisfied three basic conditions: technical feasibility, financial viability, and a completed Environmental Impact Analysis.

[12] Charrett, n 10, 193–201.

[13] Health and Safety Executive, *The Collapse of NATM Tunnels at Heathrow Airport. A Report on the Investigation by the Health and Safety Executive into the Collapse of New Austrian Tunnelling Method (NATM) Tunnels at the Central Terminal Area of Heathrow Airport on 20/21 October 1994* (2000).

[14] P Loots and D Charrett, *Practical Guide to Engineering and Construction Contracts* (CCH, 2009) 354–358.

[15] Alan Muir Wood, *Tunnelling Management by Design* (E & FN Spon, 2000) 286.

The project comprises three tunnels 50 km long, 37.9 km of them undersea. The two rail tunnels are 7.6 m diameter, and the service tunnel between them is 4.8 m in diameter. Eleven tunnel boring machines were used in their construction. The total cost of construction and financing was £12.5 billion. As the longest undersea tunnel in the world (37.9 km undersea), the Channel Tunnel was undoubtedly a technical success which delivered the quality required to satisfy the regulatory authorities. However, it was completed two years late and was 72% over budget (excluding inflation). Dispute Adjudication Boards adjudicated on 15 references associated with approximately 25% of the total cost of the project, including many disputes on legal interpretation of the meaning of the contract (which had to conform to common principles of the law of France and the law of England).

The very short time available for preparation of bids, before basic design parameters such as the tunnel diameter and the operating standards were established, played a big part in determining the ultimate project time and cost outcome.[16] In reviewing the time and cost performance on this project, Muir Wood sounded the following warning which is equally applicable to balancing the time and cost of other major projects:

> Bankers are their own worst enemies in relation to their attempts to control costs of major projects. The urge for quick results is directly contrary to the essential feature of determining beforehand what is to be done, what are the criteria for acceptability, internally and by external agents, and what are the uncertainties that may lead to risk if not managed.[17]

Cost of Design Changes

Petrobras-36

“Petrobras-36” was a semi-submersible production platform acquired, upgraded and installed for Petrobras’ operations at Roncador, offshore Brazil. It took a team of dedicated professionals many months to put in place a complicated contractual structure in 1997 for the transaction. The upgrade led to a commonplace dispute over payment for an increased scope of work beyond that originally agreed and, after a year of operations, the rig was lost in March 2001 following an explosion, which in turn led to a number of consequential issues.

The original scope of work was an upgraded rig for the South Marlim field, but Petrobras made a change to Roncador, which was newly discovered and for which only basic metocean and other data was available initially. The engineering had to be developed on the job as more data emerged. It was agreed that Petrobras would pay for the extra work of the change to Roncador. Its personnel were very closely involved in all aspects of the works. The agreements were silent with regard to any detailed regime for determining the impact of the extra work and the costs of it. The parties naively (trusting in their good relationship) provided in their agreements that Petrobras would act in good faith with regard to payment of the costs to be paid for the extra work.

The parties negotiated a “clean sweep” type arrangement in 1999 prior to completion of the upgrade to determine the extra costs due to the Contractor, which averted the need for an expensive and lengthy technical analysis of each extra required by the change to Roncador. Whilst this was regarded to be fair and reasonable by those responsible within Petrobras for negotiating it direct with the Contractor, the Board of Petrobras did not approve it. Petrobras maintained in the litigation that the settlement was not legally binding and could be disregarded for that reason.

The consequence of the *ad hoc* cost arrangements that were adopted, which in the main fell outside the terms of what had been agreed, was an expensive and lengthy investigation at trial into precisely what was said by whom and, as an incidental but crucial issue, with what authority. Petrobras succeeded in persuading the court at first instance that any binding settlement to pay the extra costs required the formal approval of the full Board of Petrobras and that any agreement made by the individual officers of Petrobras who were negotiating with the Contractor was not binding. This led to a full and costly

[16] See also Loots and Charrett, n 14, 341–344.

[17] Alan Muir Wood, *Civil Engineering in Context* (Thomas Telford, 2004) 173.

enquiry into the costs incurred by the Contractor (which it sought to avoid), subject to appeal and further issues relating to the conduct of the Petrobras board in not approving the final settlement recommended to them.[18]

Inadequate Management and Supervision of Design Team

I-35W Highway Bridge, Minneapolis United States

On 1 August 2007, the eight-lane 1,907-foot-long I-35W highway bridge over the Mississippi River in Minneapolis experienced a catastrophic failure in the main span of the deck truss. About 1,000 feet of the deck truss collapsed, with part of the main span falling 108 feet into the river. As a result of the bridge collapse, 13 people died and 145 people were injured.

The NTSB report into this tragedy determined that the probable technical cause of the collapse was an error in the design of gusset plates joining members. It also identified the following inadequacies in managing the design:

- insufficient bridge design firm quality control procedures for designing bridges;
- insufficient Federal and State procedures for reviewing and approving bridge design plans and calculations;
- lack of guidance for bridge owners with regard to the placement of construction loads on bridges during repair or maintenance activities.[19]

Inadequate Involvement of Designers in Construction

Heathrow Express Tunnel

Cost pressures on the specialist tunnel design consultant at tender time resulted in insufficient resources to provide even minimal control of the work, and it did not have appropriate powers of control over the construction. The nature of the tunnelling works required continual assessment of the support conditions appropriate for the geotechnical conditions revealed as the tunnel progressed. Muir Wood noted that as the contract required the Contractor to certify the quality of its own work, an adequate system of design control of the work should have been specified at tender time.[20] Such design control would have required extensive involvement of the designers during construction, with an appropriate level of design fees.[21]

Prior to the collapse Muir Wood had pointed out the dangers of the fragmented system of project management used for tunnelling projects in London. In highlighting the fundamental importance of the overall management of the design process, he noted that obtaining fixed costs for each fragmented activity was not conducive to either economic tunnelling or avoidance of disputes and litigation.[22]

Unavailability of Key Personnel

Fitzroy Robinson Ltd v Mentmore Towers Ltd

This United Kingdom decision deals with the issue of a party’s duty to disclose circumstances affecting the validity of a pre-contractual statement regarding key personnel. In that case the judge found that a consultant’s representations on the appointment of a particular person as the team leader was one of the main reasons for the consultant’s engagement. The key individual resigned before the consultant was

[18] P Loots and D Charrett, *The Application of Contracts in Developing Offshore Oil and Gas Projects* (Informa Law from Routledge, 2019) 214–218.

[19] National Transportation Safety Board, *Collapse of I-35W Highway Bridge Minneapolis, Minnesota August 1, 2007* (Highway Accident Report NTSB/HAR-08/03 PB2008-916203, 2008).

[20] Muir Wood, n 17, 285–288.

[21] Loots and Charrett, n 14, 341–344.

[22] Muir Wood, n 17, 272.

engaged, but the Employer was not advised. The judge held this to be a fraudulent misrepresentation and awarded damages for consultant's fees arising from the disruption and duplication of work.[23]

Late Receipt of Drawings

FG Minter v Welsh Health Technical Services Organisation

Clauses 11(6) and 24(1) of the 1963 RIBA/JCT forms of contract entitled the Contractor to be paid "direct loss and expense" not reimbursable under the variation valuation rules, or as a result of disturbance of progress due to late receipt of drawings and information from the architect. The Contractor claimed financing charges on the additional expenditure involved under both clauses as sums due and to be certified by the architect.

The Court of Appeal held that the loss of interest on the additional capital the Contractor was forced to borrow or on capital it was not free to invest was recoverable on an Employer's breach of contract, so that interest on its working capital up to the date of certification of the Contractor's claim by the architect was recoverable under the wording of the clauses.

In such circumstance the Employer may be able to recover the "direct loss and expense" it has to pay to the Contractor as a consequence of the late delivery of the drawings from the architect in an action for breach of contract or negligence.[24]

Late Revision of Drawings

McAlpine Humberoak Ltd v McDermott International

A lump sum tender for the onshore construction of nine steel pallets forming part of the weather deck for the tension leg platform on the Hutton oil field in the North Sea was accepted on the basis of some 22 drawings. Between November 1981 and March 1982, when the contract was signed, some 139 revised drawings had been issued, with the number of pallets reduced to two, and the original completion date for those two pallets (by February 1982) already passed, so that time was at large. By cl 35 of the contract the Contractor was entitled to compensation for all changes in the work and every drawing issued was given a variation instruction status. The two pallets were eventually delivered in July and September 1982.

The Court of Appeal held that the revised drawings had not frustrated the Contract, which required the contract sum to be adjusted in the light of a detailed examination and assessment of the effect of the various drawings and changes made by the owners. The contract provided for full compensation for all changes, and that any late information breaches of contract could be recovered as damages. Lloyd LJ considered the correct approach to valuing the compensation for all changes was "a retrospective and dissectional reconstruction by expert evidence of events almost day by day, drawing by drawing, TQ by TQ, and weld procedure by weld procedure".[25]

Designer Not Fulfilling Contractual Obligations of Supervision

de la Concorde Overpass

The de la Concorde Overpass was a prestressed concrete bridge over Autoroute 19 in the province of Quebec, built in the early 1970s, and designed and constructed generally in accordance with the standards prevailing at that time. In 2006 a span collapsed under light traffic load, killing five people. The Government of Quebec established a Commission of Inquiry, comprising an attorney as President, and two engineers as Commissioners.[26]

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[23] *Fitzroy Robinson Ltd v Mentmore Towers Ltd* [2009] EWHC 1552 (TCC).

[24] *FG Minter v Welsh Health Technical Services Organisation* (1980) BLR 1.

[25] *McAlpine Humberoak Ltd v McDermott International* (1992) 58 BLR 1 (CA) (Civ Div).

[26] Quebec Canada, *Commission of Inquiry into the Collapse of a Portion of the de la Concorde Overpass, Report* (2007).

The Commission concluded that, whilst there were a number of defects and shortcomings, both technical and procedural, none of those by itself would have caused the collapse, which resulted from a chain of causes.[27] The technical causes of the collapse included both deficiencies in design and construction.

Amongst the procedural failures identified by the Commission was the failure of the consulting engineer for not fulfilling its contractual obligation to exercise full-time supervision of the construction of the overpass, and thereby not preventing the faulty installation of the reinforcement that resulted in the structure not complying with the drawings and specifications.[28]

CASE STUDIES ON TECHNICAL RISKS

There are many case studies of projects in which technical risks have materialised and resulted in failure, that is a perceived shortfall in one or more of the contractual expectations in respect of time, cost and/or quality. The following list enumerates a few such case studies, under the categories of technical risk identified above:

- poor quality design – Boston Big Dig,[29] National Physical Laboratory United Kingdom,[30] I-35W Highway Bridge, Minneapolis United States,[31] Grayston Bridge temporary works South Africa,[32] Opal Towers Sydney;[33]
- design errors – Brisbane Airport Link,[34] *Arkuthun Dagi*,[35] Quebec Bridge,[36] West Gate Bridge,[37] Miami Pedestrian Bridge;[38]
- inadequate checking of computer analysis of design – Hartford Civic Centre;[39]
- inadequate checking by designer of contractor's shop drawings – Hyatt Regency Hotel walkways;[40]
- inadequacy of design knowledge or standards – *MT Hojgaard v E.ON Climate & Renewables*,[41] AQ1 Ronan Point tower,[42] Quebec Bridge;[43]
- buildability – *Thorn v London City Council*;[44]
- cost of implementing final design – *Leighton Contractors v Kinhill Engineers Pty Ltd*.[45] AQ2

[27] Quebec Canada, n 26, 5.

[28] Charrett, n 10, 268–270.

[29] Loots and Charrett, n 14, 347–349.

[30] National Audit Office, *The Termination of the PFI Contract for the National Physical Laboratory* (10 May 2006) <https://www.nao.org.uk/report/the-termination-of-the-pfi-contract-for-the-national-physical-laboratory/>.

[31] National Transportation Safety Board, n 19.

[32] Antoinette Slabbert, "Damning Report into M1 Highway Bridge Collapse That Killed Two", *News24*, 2 December 2019 <https://www.news24.com/citypress/business/damning-report-into-m1-highway-bridge-collapse-that-killed-two-20191202>.

[33] Unisearch, *Opal Tower Investigation Final Report* (Independent Advice to NSW Minister of Planning, 2019).

[34] Charles O'Neill, *Global Construction Success* (John Wiley & Sons Ltd, 2019) 28.

[35] Loots and Charrett, n 18, 131.

[36] Charrett, n 10, 271–283.

[37] Charrett, n 10, 284–300.

[38] National Transportation Safety Board, *Pedestrian Bridge Collapse Over SW 8th Street Miami Florida March 15, 2018* (Accident Report NTSB/HAR-19/02 PB2019-101353, 2019).

[39] Charrett, n 10, 266.

[40] Charrett, n 10, 266.

[41] Charrett, n 10, 95–104.

[42] Charrett, n 10, 261–266.

[43] Charrett, n 10, 271.

[44] Loots and Charrett, n 18, 57; *Thorn v London City Council* (1876) App Cas 120.

[45] Charrett, n 10, 109; *Leighton Contractors v Kinhill Engineers Pty Ltd* (1996) 12 BCL 415.

CONCLUSION

The thesis of the article is that both design management risk and technical risks can generally be managed successfully by using an appropriate design contract to engage a qualified Designer who applies established risk management procedures and complies with the design contract.[46]

In this writer's experience a design contract will generally be successful if the Employer and the Designer get the design contract right before it is executed and work commences, and the parties subsequently execute the contract in accordance with its terms.

Getting the contract right requires engaging a Designer with the appropriate technical and managerial skills to deliver the design to the requisite quality within a reasonable time period for which it is paid an adequate fee. It entails defining the scope of work clearly and unambiguously and assigning the risks in accordance with the Abrahamson principles.

Executing the contract in accordance with its terms requires the Designer to plan and manage the time, cost and quality of the design, employ an adequate number of staff with the relevant technical skills, implement appropriate procedures to ensure the required quality of design and communicate progress and unforeseen issues to the Employer. The Employer will need to provide timely information to the Designer and comply with its other contractual obligations, including timely payment to the Designer.

Nevertheless, as some of the case studies referred to above illustrate, there are occasionally unknown knowns or unknown unknown risk events that materialise in spite of good risk management and technical skills, the financial consequences of which will ultimately be determined by the contract.

[46] Rob Horne, "The Contract as the Primary Risk Management Tool" in Charles O'Neill (ed), *Global Construction Success* (John Wiley & Sons Ltd, 2019) 117.